AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 100:389–396 (1996)

Skeletal Growth of Children From the Iron Age Site at K2 (South Africa)

MARYNA STEYN AND MACIEJ HENNEBERG
Department of Anatomy, University of Pretoria, Pretoria, 0001, (M.S.) and Biological Anthropology Research Programme, University of the Witwatersrand, Medical School, Parktown, 2193 (M.H.) South Africa

KEY WORDS Community health, Allometry, Mapungubwe, Long bone

ABSTRACT Cross-sectional growth data were obtained from the skeletal remains of children from the Iron Age site of K2 near the Limpopo River. Standard measurements of the diaphyseal lengths of the long bones from both limbs were recorded and compared to published skeletal data. For this purpose, data on Eskimo and Aleut skeletons, Libben skeletons, and skeletons from Indian Knoll and Altenerding were used. An attempt to study growth allometrically was made. K2 children were growing as well as children from these other groups. Comparison of data for K2 children with those on living South African "Cape Coloured" rural children, studied during the late 1980s, shows the similarity of growth of both groups.

It is only recently that juvenile skeletons have been included in population studies of prehistoric people, placing population differences and similarities in growth and development under study. These kinds of investigations are mainly used to examine the adequacy of growth, in order to gain insight into overall community health and adaptation to the environment (Johnston, 1968; Johnston and Zimmer, 1989). Realizing the value of such studies in reconstructing health changes and nutritional status of past populations, a number of studies have been published (e.g. Johnston, 1962; y'Edynak, 1976; Merchant and Ubelaker, 1977; Sundick, 1978; Jantz and Owsley, 1984; Lovejoy et al., 1990; Hoppa, 1992; Saunders et al., 1993; Miles and Bulman, 1994).

The assessment of growth in prehistoric populations, however, is not without problems. Skeletal samples are generally numerically restricted due to poor preservation of young children's skeletons and low mortality in the adolescent age groups. Difficulties may also arise from lack of proper standards for aging. Sexing of juvenile skeletons has always been difficult. The possible presence of secular trends makes comparisons between various groups difficult (Johnston, 1968; Sundick, 1978).

One of the most serious problems arises from the fact that the juvenile skeletal sample represents only those individuals who died in childhood, and not necessarily the normal, healthy children in the community. The mere presence of an individual in the skeletal sample indicates that he/she had a disease or died of other causes, and the possibility exists that this disease might have retarded the growth of the individual. According to Buikstra and Cook (1980), these juveniles represent the "minima" rather than the "modes" of those who survived. Wood et al. (1992) also argued that the bony lesions observed and long-bone growth might not reflect the true health status of a

Received November 7, 1994; accepted December 17, 1995.

Address reprint requests to M. Steyn, Department of Anatomy, P.O. Box 2034, University of Pretoria, 0001, South Africa.

Maciej Henneberg's current address is Department of Anatomy and Histology, University of Adelaide Medical School, Adelaide 5005, South Australia.

group of people. They stated that "If mortality slackens, only the most frail (i.e., short-statured) individuals die. Periods of low mortality are therefore characterized by comparatively low mean stature among the dead" (p. 351).

Lovejoy et al. (1990), however, believe that children are more likely to die of acute rather than chronic diseases, which would not have altered their maturation in any way. Sundick (1978) also found that children with more frequent illnesses compare well, as far as height is concerned, with those who were healthier (also Henneberg et al., 1984). In a review paper on the issue of mortality bias and its influence on growth data, Saunders and Hoppa (1992) found that although the potential for such a bias exists, its effects are likely to be small.

No major differences have ever been detected between the pattern and direction of growth when modern and prehistoric groups are concerned, although many prehistoric peoples appear to be shorter than their modern counterparts (Frayer, 1984; Saunders, 1992). This, however, is not an absolute rule, as in many populations body size has been found to decline since the Upper Paleolithic to Medieval times (Frayer, 1984; Jacobs 1985; Brown, 1992) or to remain stable over thousands of years (Henneberg and Henneberg, 1990, Henneberg et al., 1992). While the documentation of age and sex of juvenile skeletons is not reliable enough to allow detailed analysis of the growth process itself (Johnston and Zimmer, 1989), studies of growth of children, based on skeletal samples, can be used to provide general information on the growth pattern in a given population, and thus allow some conclusions to be drawn on the relationship between a population and its environment. Average differences in growth between groups are most probably due to differences in the environment, although there are indications that population-characteristic body proportions are established early in childhood (y'Edynak, 1976).

In a recent paper, Sciulli (1994) pointed out that all bones are not equally affected by nutritional and disease stress, and that the most rapidly growing bones are more influenced than others. The bones of the lower limb (in the sequence of femur; fibula; tibia) will therefore be relatively smaller in unfavorable conditions than those of the upper limb. This can be tested by means of allometric analysis, e.g., studying the growth of the femur against that of the humerus.

The aim of this study is to compare the infracranial growth of children from the Iron Age site of K2 to that of others, in order to gain insight into their overall health status.

The Iron Age site of Mapungubwe is situated in the Northern Transvaal, close to the border between South Africa, Botswana and Zimbabwe. It consists of two valleys: K2 and the Southern Terrace, with the Mapungubwe Hill towering over the latter. The valley called K2 was inhabited from about AD 1000 to 1200. Later, most of the occupation shifted to an adjacent valley, the Southern Terrace. During this time, the Mapungubwe Hill itself was occupied (Eloff, unpublished) by people of exalted social status. The complex was abandoned around 1300.

The valley of K2 was densely inhabited, and it has a distinct midden in the middle of the settlement which is up to 6 m deep. The Mapungubwe complex of sites was the center of economic and political power during the period of its occupation (Hall, 1987). Ivory and bone tools were traded with East Coast merchants. Large herds of cattle were kept, and it can be expected that the meat of domesticated animals and milk formed a substantial part of the diet (Eloff, unpublished; Voigt, 1983). This was supplemented by sorghum, millet and beans.

The decline of the settlements coincides with the rise of the Great Zimbabwean Empire. A more complete description of the site can be found in Henneberg and Steyn (1994).

Excavations were conducted at the sites by the University of Pretoria from the 1930s. They yielded the 106 skeletons used in this study. This is the largest collection of skeletons from a single Iron Age site in Southern Africa. Ninety-four of these skeletons came from K2 and twelve from the Mapungubwe Hill. No skeletons from the Southern Terrace have yet been discovered. Previous studies of this material have mostly centered around the establishment of racial affinity (Galloway, 1959; Rightmire, 1970; De Villiers, unpublished).

This assessment of the growth of K2 skeletons forms part of a larger study, in which various aspects pertaining to demographic dynamics, health, nutrition and adaptation are addressed (Henneberg and Steyn, 1994; Steyn, unpublished; Steyn and Henneberg, 1995, 1996). Paleodemographic analysis indicated a high rate of natural increase, mortality typical for preindustrial societies, newborn life-expectancy around 20 years, and less than 50% survivorship to sexual maturity (Henneberg and Steyn, 1994). Although the people were not free from disease, it seems they were relatively healthy (Steyn and Henneberg, 1996).

MATERIALS AND METHODS

The state of preservation of the remains of the 106 individuals ranged from only a few teeth to almost complete skeletons. The Mapungubwe skeletons particularly are in a very bad condition, while the K2 ones, found in the ash heaps, are in a much better condition. Therefore, the Mapungubwe skeletons, with only five subadult individuals, were not included in the study of growth. It seems that the custom of burying the dead in ash heaps, which create an alkaline environment, contributed to the good preservation of a large number of infant and child skeletons.

In a study of growth, reliable age-at-death estimates are important. Skeletal age cannot be used as an indicator of chronological age here, as it would lead to circular reasoning (Johnston and Zimmer, 1989; Saunders, 1992). Thus, the dental age was used. Dental age also varies in different environments and populations, but to a lesser degree than does skeletal age (Sundick, 1978). Only bones of individuals with teeth preserved well enough to allow determination of dental age were used in this study. Each individual was thus aged according to the eruption and formation of teeth (Ubelaker, 1989; El-Nofely and Iscan, 1989). In the case of newborn individuals, only those with tooth germs available were used.

Incompletely preserved skeletons of 45 subadult individuals of dental age from 0 to 18 years were used. There were 30 humeri, 26 radii, 24 tibiae, 22 ulnae, 19 femora, and 17 fibulae available for observation. All diaphyseal lengths of complete long bones were measured using an osteometric board. Results were then plotted on a graph by dental age, and compared with available data from other skeletal samples. For these comparisons, data on Libben (Lovejoy et al. 1990), the Eskimo and Aleut (y'Edynak, 1976), as well as those of children from Indian Knoll and Altenerding, Germany (Sundick, 1978) were used. These particular samples were chosen because they represent a wide variety of populations from different geographical areas. Also, aging techniques for these studies differed; for example, the Eskimo and Aleut samples (y'Edynak, 1976) were aged by a combination of dental and skeletal indicators, while Libben (Lovejoy et al. 1990), Alterneding, and Indian Knoll (Sundick, 1978) were mostly aged by teeth alone.

Allometric growth was observed by plotting diaphyseal length of one long bone against that of another one, irrespective of the age of the individual. In this way, the effect of possible erroneous ageing is eliminated, while differential growth of bones may be indicative of environmental influences (Sciulli, 1994). In general terms this method completely eliminates the chronological age from the growth study and concentrates only on the proportional growth of one body part against the other. When the same individual had, for example, lengths available for both a humerus and a femur, the length of the femur was plotted on a graph against the length of the humerus.

These allometric plots were compared to the same groups as before. The data for these groups are published as averages from each year of chronological age. Use of such averages for comparison with allometric plots of individuals may be questioned. Fortunately small samples in published data resulted in some age categories being represented by only one individual. These individual data were plotted against K2 (Fig. 5).

Although it is not possible to compare skeletal samples to living groups in a straightforward way (Johnston and Zimmer, 1989), long-bone lengths of K2 children were also plotted on the same graph as limb segment lengths of rural Cape "Coloured" children from South Africa (M. Henneberg, unpub-

TABLE 1. Diaphyseal lengths in millimetres

Age group (years)	Humerus			Radius			Ulna			Femur			Tibia			Fibula		
	n	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s
Newborn/fetal	4	67.4	7.37	3	56.3	7.04	3	62.9	6.75	3	75.9	7.37	4	66.4	6.36	2	59.9	2.90
Newborn–0.5	2	85.2	0.85	1	66.3		1	76.3		1	100.5		1	89.0				
0.5–1.5	6	97.9	6.90	5	82.6	6.81	3	93.3	5.34	5	125.0	6.90	4	108.3	7.41	4	97.7	7.85
1.5–2.5	1	107.0		2	85.0	1.00	2	95.8	1.25	1	130.0		1	107.5		1	114.0	
2.5–3.5	2	118.5	7.50	2	113.8	14.75	2	124.4	12.60				2	147.5	10.00	1	131.5	
3.5–4.5	3	144.8	10.59	3	112.6	2.41	2	120.0	7.50	3	197.4	7.85	4	158.7	9.94	2	161.2	4.75
4.5–5.5	2	150.0	5.00	2	120.2	4.75	1	130.0		1	193.0							
5.5–6.5	2	158.0	0	1	130.5		1	142.0		2	229.0	6.00	2	188.8	4.25	2	188.2	3.65
6.5–7.5	1	191.5		1	157.0		1	172.0					1	219.3				
7.5–8.5	1	182.0		1	141.8		1	157.0		1	257.0		1	210.0		1	204.0	
8.5–9.5	1	198.0		1	161.0		2	173.7	3.65				1	230.0		2	227.5	1.50
9.5–10.5	1	210.5		1	181.5		1	198.8					1	245.0				
10.5–11.5																		
11.5–12.5																		
12.5–13.5	1	249.3		1	202.0		1	207.5		1	381.3		1	325.5		1	284.0	
13.5–14.5	1	260.5		1	175.0					1	352.0		1	294.0				
14.5–15.5																		
15.5–16.5																		
16.5–17.5	2	286.8	6.75	1	215.5		1	251.0								1	317.5	

lished data). This cannot be used to make comparisons on absolute lengths, but may provide information on the similarity, or lack thereof, of growth patterns between these prehistoric and modern groups.

RESULTS

Data for the lengths of the various long bones at different ages is shown in Table 1. On all the plots of long bone lengths against skeletal age, K2 children's bones were as long, or even slightly longer, than those of the other groups. It seems that data for Libben (Lovejoy et al., 1990) are the closest to our observations. Figures 1 and 2 illustrate the growth of the femur and humerus, and Figures 3 and 4 those of the distal limb segments, namely ulna and tibia.

As far as the comparisons of allometric growth are concerned (see Fig. 5 as an example of the length of the femur vs. that of the humerus), it seems that children from K2 grew in a fashion similar to those from other populations, although the number of individuals that could be used for comparison is small. The same can be said for the comparison with the growth of K2 and Cape "Coloured" children, once allowance has been made for soft tissues and epiphyses (Figs. 6 and 7 present examples of lengths of the forearm and upper leg).

DISCUSSION

Studies of skeletal growth are often hampered by small sample sizes. This is also true of the K2 sample. In the case of the K2 material, however, such an investigation was deemed to be important because it is the largest collection of its kind from this part of the world, and is also to the authors' knowledge the first such study from southern Africa. Even though the sample sizes are small, it does seem as if the children from K2 were a bit taller than those, for example, from the Eskimo and Indian sample groups. Of the four groups compared, the Libben group seems to be the closest in length to the children from K2, followed by Altenerding. If it is true that long-bone length reflects something of the living conditions, then it seems as if the children from K2 were as well off, if not better, as those of the other samples they were compared with. The sample sizes presented in this study, however, are not large enough to fully justify this conclusion beyond suggestion.

This conclusion is corroborated by the results of the paleopathological study, which indicated that the people were relatively healthy (Steyn and Henneberg, 1996). Although the people were not free of disease, incidences of cribra orbitalia, enamel hypoplasia, and transverse radio-opaque lines

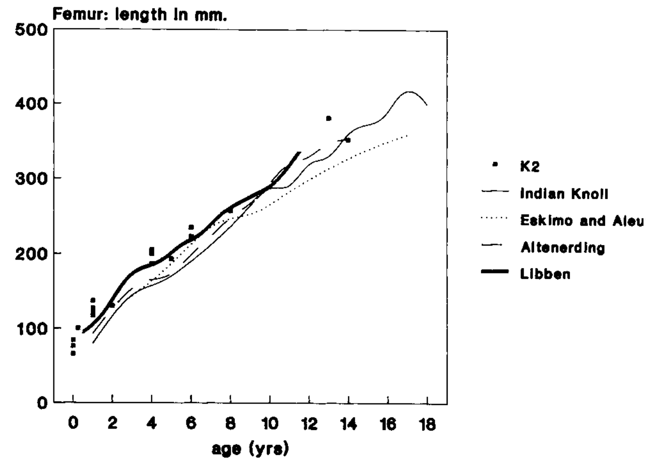

Fig. 1. Diaphyseal growth of the femur.

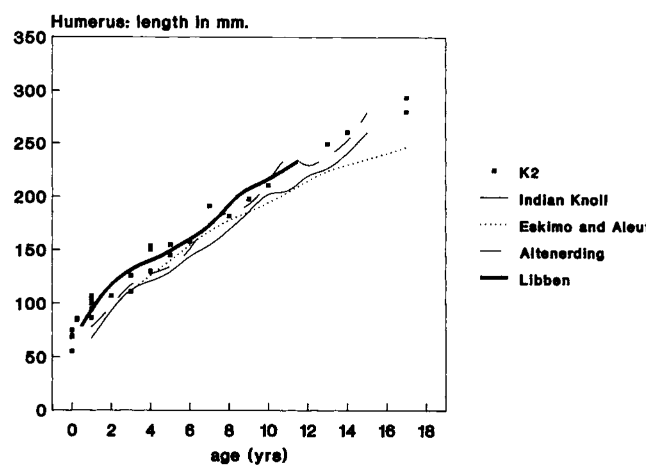

Fig. 2. Diaphyseal growth of the humerus.

were not very high. Few signs of chronic disease, in the form of subperiosteal bone growth, were observed. This was especially true in the case of the children, where only two, showing subperiosteal bone growth, out of a total of 44 children with long bones, had any signs of disease at all. Chronic diseases might have been more common in adults, where four out of the eight adults with long bones were affected. It has been suggested that these bony lesions might have been due to the presence of treponemal disease (Steyn and Henneberg, 1995).

It is generally accepted that the health of people declined with the transition from a hunting-and-gathering to agriculturalist mode of subsistence (e.g., Cohen and Armelagos, 1984). In the case of the people from the Mapungubwe complex of sites, however, it may be proposed that the more sedentary lifestyle did not lead to deterioration in general health, due to the presence of large herds of domesticated animals. This ensured the presence of a constant protein-rich food supply (Steyn and Henneberg, 1996).

Although the comparison of growth with

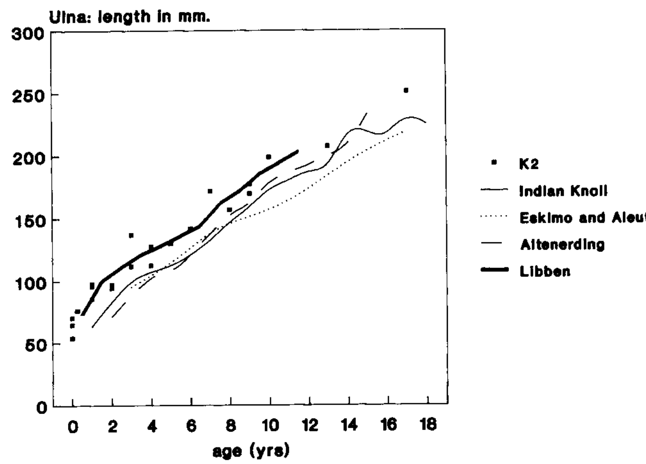

Fig. 3. Diaphyseal growth of the ulna.

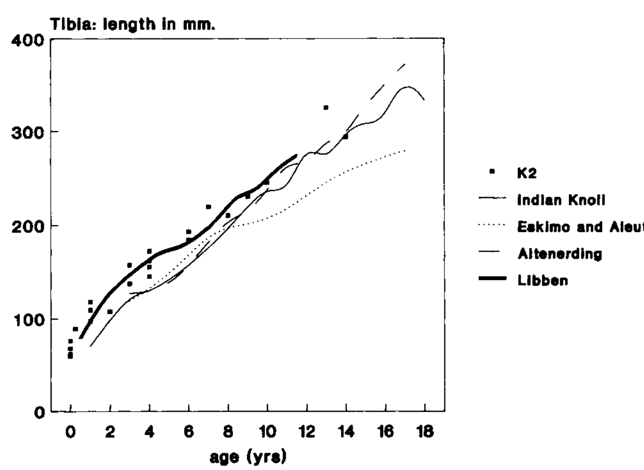

Fig. 4. Diaphyseal growth of the tibia.

the "Coloured" children is probably not detailed or refined enough to pick up smaller differences in growth patterns, the overall tempo and mode of growth are rather similar in the limited age range for which data are available. Comparisons of allometric growth also indicate similarity between K2 and other groups. Sciulli (1994) has postulated that in poor living conditions, lower limbs should be shortened relative to the upper ones. Our allometric comparisons do not reveal such a tendency in K2. Therefore, it may be suggested that conditions in which K2 children grew were similar to those in other groups.

Saunders (1992) mentioned that no significant differences have ever been detected in direction and pattern of growth between different groups, and this seems to be substantiated by the results of this study. Although some differences between populations in length of a particular bone by age can be observed, the tempo of growth as well as the relationship between the growth of different bones seem to be very similar for all groups considered. It seems, therefore, that with

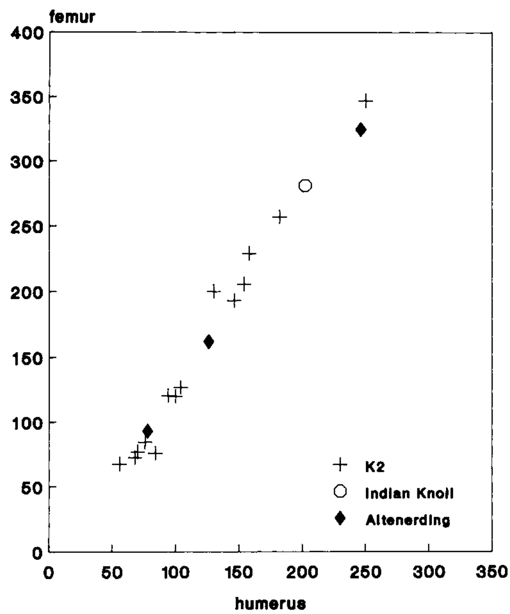

Fig. 5. Allometric growth: femur vs. humerus.

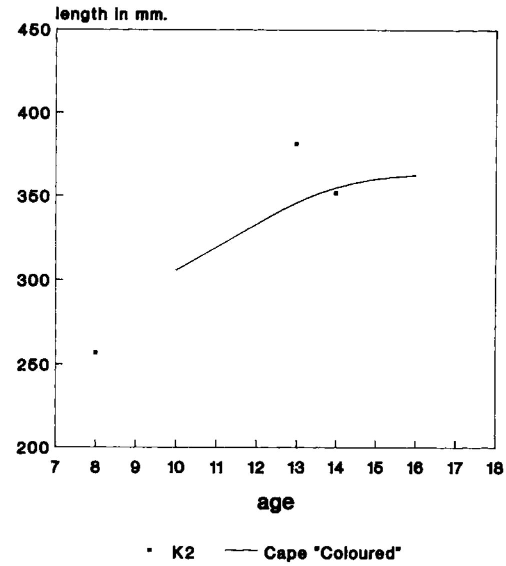

Fig. 7. Growth of the femur in K2 skeletons compared with upper leg (symphysion-tibiale) growth of Cape "Coloured" children.

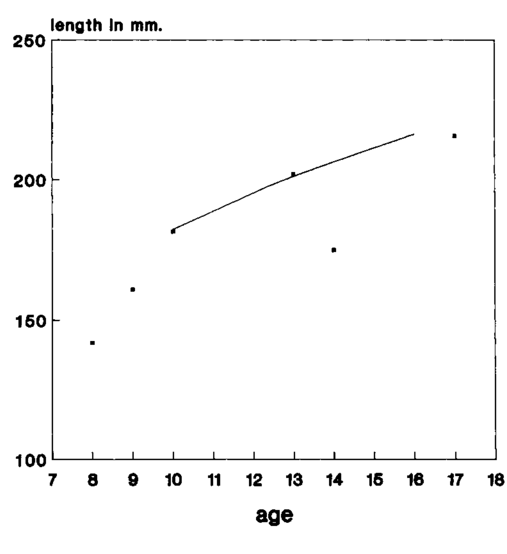

Fig. 6. Growth of the radius in K2 skeletons compared with forearm (radiale-stylion) growth of Cape "Coloured" children.

small samples available in skeletal series one either cannot detect minute differences in growth of various human groups, or that no substantial differences in child growth existed in prehistoric and early historic populations. Similar growth of children in such disparate populations as American Indians, Medieval Germans, Iron Age and modern Africans indicates that most human populations were capable to provide their young with similar conditions for development.

ACKNOWLEDGMENTS

The authors thank the University of Pretoria Research Committee Fund (through M. Steyn), the FRD (through M. Henneberg) and the Department of Anatomy and Human Biology Research Incentive Fund for financial assistance. We are also indebted to Mrs. A. Van Heerden and Mrs. M. Hoffmann for technical assistance. Comments of the two anonymous referees helped to improve the paper.

LITERATURE CITED

Brown P (1992) Recent human evolution in East Asia and Australasia. Phil. Trans. Roy. Soc. Lond. *337:* 235–242.

Buikstra JE, and Cook CD (1980) Paleopathology: An American account. Ann. Rev. Anthropol. *9:*433–470.

Cohen MN, and Armelagos G (1984) Paleopathology at the Origins of Agriculture. Orlando: Academic Press.

El-Nofely AA, and Iscan MY (1989) Assessment of age

from the dentition in children. In MY Iscan (ed): Age Markers in the Human skeleton. Springfield: Charles C Thomas, pp. 237–254.

Frayer D (1984) Biological and cultural change in the European Late Pleistocene and Early Holocene. In: FH Smith and F Spencer (eds): The Origins of Modern Humans: A World Survey of the Fossil Evidence. New York: Alan R. Liss, pp. 211–250.

Galloway A (1959) The skeletal remains of Bambandyanalo. Johannesburg: Witwatersrand University Press.

Hall M (1987) The Changing Past: Farmers, Kings and Traders in Southern Africa 200–1860. Cape Town: David Philip.

Henneberg M, and Henneberg RJ (1990) Biological characteristics of the population in the Chora. In JC Carter (ed): The Pantanello Necropolis. Austin: Texas University Press, pp. 76–92.

Henneberg M, and Steyn M. (1994) Preliminary report on the Paleodemography of the K2 and Mapungubwe populations (South Africa). Hum. Biol. *66:*105–120.

Henneberg M, Budnik A, Pezaka M, and Puch AE (1984) The mechanism of brachycephalization: Differential susceptibility to infectious diseases during childhood. A preliminary report. Przeglad Antropologiczny *50:* 325–333.

Henneberg M, Henneberg RJ, and Carter JC (1992) Health in Colonial Metaponto. National Geographic Research and Exploration *8:*446–459.

Hoppa RD (1992) Evaluating human skeletal growth: An Anglo-Saxon example. Int. J. Osteoarchaeol. *2:* 275–288.

Jacobs K (1985) Climate and hominid postcranial skeleton in Würm and Early Holocene Europe. Curr. Anthropol. *26:*512–514.

Jantz RL, and Owsley DW (1984) Long bone growth variation among Arikara skeletal populations. Am. J. Phys. Anthrop. *63:*13–20.

Johnston FE (1962) Growth of the long bones of infants and young children at Indian Knoll. Am. J. Phys. Anthrop. *20:*249–254.

Johnston FE (1968) Growth of the skeleton in earlier peoples. In DR Brothwell (ed): The Skeletal Biology of Earlier Human Populations. Oxford: Pergamon Press, pp. 57–66.

Johnston FE, and Zimmer LO (1989) Assessment of growth and age in the immature skeleton. In MY Iscan and KAR Kennedy (eds): Reconstruction of Life from the Skeleton. New York: Alan R. Liss, pp. 11–21.

Lovejoy CO, Russell KF, and Harrison ML (1990) Long bone growth velocity in the Libben population. Am. J. Hum. Biol. *2:*533–541.

Merchant VL, and Ubelaker DH (1977) Skeletal growth of the protohistoric Arikara. Am. J. Phys. Anthrop. *46:*61–72.

Miles AEW, and Bulman JS (1994) Growth curves of immature bones from a Scottish Island population of sixteenth to mid-nineteenth century: Limb-bone diaphyses and some bones of the hand and foot. Int. J. Osteoarch. *4:*121–136.

Rightmire GP (1970) Iron Age skulls from Southern Africa reassessed by multiple discriminant analysis. Am. J. Phys. Anthrop. *33:*147–168.

Saunders SR (1992) Subadult skeletons and growth related studies. In SR Saunders and MA Katzenberg (eds.): Skeletal Biology of Past Peoples: Research Methods. New York: Wiley-Liss, pp. 1–20.

Saunders SR, and Hoppa RD (1993) Growth deficit in survivors and non-survivors: Biological mortality bias in subadult skeletal samples. Yrbk. Phys. Anthropol. *36:*127–151.

Saunders SR, Hoppa R, and Southern R (1993) Diaphyseal growth in a nineteenth century skeletal sample of subadults from St. Thomas' Church, Belleville, Ontario. Int. J. Osteoarch. *3:*265–281.

Sciulli PW (1994) Standardization of long bone growth in children. Int. J. Osteoarch. *4:*257–259.

Steyn M, and Henneberg M (1995) Pre-Columbian presence of treponemal disease: A possible case from Iron Age Southern Africa. Curr. Anthropol. *36:*869–873.

Steyn M, and Henneberg M (1996) The health status of the people from the Iron age sites at K2 and Mapungubwe. Rivista di Antropologia (in press).

Sundick RI (1978) Human skeletal growth and age determination. Homo *29:*228–249.

Ubelaker DH (1989) Human Skeletal Remains. Second Edition. Washington: Taraxacum.

Voigt EA (1983) Mapungubwe: An Archaeo-zoological Interpretation of an Iron Age Community. Pretoria: Transvaal Museum.

Wood JC, Milner GR, and Harpending HC (1992) The osteological paradox: Problems of inferring prehistoric health from skeletal samples. Curr. Anthrop. *33:* 343–370.

y'Edynak G (1976) Long bone growth in Western Eskimo and Aleut skeletons. Am. J. Phys. Anthrop. *45:* 569–574.